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THE ECOLOGY OF THE SPIDERS OF THE XERIC DUNELANDS IN THE CHICAGO AREA

BY

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Howard K. Gloyd, Director of the Museum

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The taxonomy of the spiders of North America has been studied by many workers since the early Nineteenth Century. Ecological works, however, are still very few. Usually the araneida are mentioned as parts of a larger study of the entire population of an area (Shelford, 1913; Adams, 1915; Holmquist, 1926), or of a specific association (Blake, 1926; Hart and Gleason, 1907; Sanders and Shelford, 1922; Vestal, 1913; Weese, 1924). The foredunes and black oak dunes of the Chicago area have been treated in studies of the Coleoptera (Park, 1930), ants (Talbot, 1934), and Orthoptera (Strohecker, 1937b) of the entire dunes succession.

Elliott (1930) has studied the spiders of a beech-maple forest. However, the spider fauna of the black oak dunes never has been considered exclusively. The present material is the outgrowth of the general collecting of spiders in the Chicago area. Early in the study, attention was called to the Kankakee dunes, the Dune Acres (Mineral Springs) dunes, and the Waukegan dunes, all of which are essentially black oak dunes with different topography and surroundings. A comparison of the areas, as well as an analysis of the characteristics of spiders of dry, open lands, as illustrated by these black oak dunes spiders, was made and is the basis of this report.

To Dr. Alfred Emerson and Dr. W. C. Allee I am grateful for many helpful suggestions throughout the progress of this study. I am indebted to Miss E. C. Bryant, Dr. B. J. Kaston, Dr. W. M. Barrows, Dr. A. M. Chickering, and especially to Dr. W. J. Gertsch, for aid in

identification of specimens and advice regarding various taxonomic matters. Dr. Sewall Wright and Dr. J. J. Schwab have been helpful with statistical problems. For indispensable assistance in the preparation of the manuscript I wish to express sincere appreciation to my wife, Audrey Stephens Lowrie.

FLORA AND TOPOGRAPHY OF THE DUNE AREAS

The dune areas considered in this work are three in number—the Waukegan flats or moorland, just north of the town of Waukegan, Illinois; the Kankakee dunes, in what was the Kankakee marshlands, seven to ten miles south of Momence, Illinois, between the villages of Wichert and Hopkins Park; the Indiana dunes at Dune Acres (Mineral Springs), Indiana.

The Waukegan moorland, along the beach in Lake County, Illinois, consists of a strip of alternating sandy ridges and marshy sloughs extending from the northern limits of Waukegan to the southern part of Zion; the strip is about three miles long and one mile wide. Marshy, interdunal pannes, parallel to the beach, have become quite dry during recent summers, though, in the past, they remained wet throughout all seasons. The most extensive marshy regions, farthest from the beach, near the abrupt old Lake Chicago shore, remain wet throughout the year, even at the present time. The last quarter-mile of dunes near the lake is entirely sand-covered, except for the course of Dead River. This slow-flowing stream imperfectly drains the low-lying inland marshes, and it is of importance in this study, because it provides an area of humidity, acting as a reservoir for species requiring humid conditions. To this extent, the study is not entirely confined to dry, open lands. These marshy places, found in all three dune areas, are reservoirs for mesic animals which continually invade the xeric dunelands, but which are never really characteristic of the dunelands. The sandy ridges of the flats are the result of the action of wind and waves in a manner similar to that producing the dunes of the southern shores of Lake Michigan (Fryxell, 1927; Cressy, 1928). The dominant trees are the black and bur oak (*Quercus velutina* and *Q. macrocarpa*), with willow (*Salix* sp.), cottonwood (*Populus deltoides*), and ash (*Fraxinus* sp.) in the lower, more moist parts. An artificial growth of conifers dominates the landscape south and west of the river (Pepoon, 1927).

Along the southern and eastern shores of Lake Michigan are found the well-known sand dunes of Michigan and Indiana. In this study, the investigation has been limited to a section which is fairly uniform in

vegetation and topography, and similar to the Waukegan flats. This area was chosen also because it has been little disturbed by man. The Dune Acres property, located in Porter County, Indiana, has been changed very little except for a small area, one-eighth of a square mile, where cottages have been erected. The area which has been studied covers about two square miles—one mile deep and two miles along the lake shore. Here the sand ridges are the highest of the three areas concerned, rising in places to 200 feet above the lake level, while at Waukegan and Kankakee, the dunes are no more than twenty to thirty feet high. The dominant tree in the Dune Acres area is the black oak, although there are also cottonwood, pine (mainly *Pinus strobus*), sassafras, (*Sassafras variifolium*), birch (*Betula alba* var. *papyrifera*), beech (*Fagus grandifolia*), and white and red oak (*Quercus alba* and *Q. borealis* var. *maxima*) in localized areas. At the inland edge of the area is an extensive quaking bog. This bog and the marshy areas at Waukegan have not been included in this study. At the western boundary of Dune Acres is a very shallow, mud-bottomed lake (Goose or Mud Lake). The eastern boundary continues on for a mile to the Indiana Dunes State Park.

The Kankakee dune area is much less well-defined than the other areas studied, but it is much more uniform. The sand dunes here are not arranged in parallel ridges, but rather in an irregular pattern. They were formed along the edges of the Kankakee River marshes which have been drained and are now largely gone, except for some scattered, low areas where water remains for part of the year. Most of the sections 19, 20, 29, and 30 of Pembroke Township, Kankakee County (about three square miles in all), are typical black oak sand dunes. These wooded areas of gently rolling dunes are covered with black oak and an occasional cottonwood.

From the above descriptions, it may be concluded that the three areas are largely similar in that they consist of black oak sand dunes with more or less extensive marshy areas. The shrub zones are negligible, as compared with most other forests of this region. During the day, the territory is mainly xeric, as the sand at the surface may reach a temperature of 64° C. (Strohecker, 1937a). This high temperature, high evaporation rate (11 cc. per day, second only to the poplar and beach dunes, according to Fuller, 1914), and sparse vegetation make these areas dry, open lands. On the other hand, at night the temperature drops greatly (Strohecker, 1937a), causing a rise in humidity, so that species which hide throughout the day in leaf mold, under loose bark, and in rotting logs or burrows, may come out and be active in a mesic climate.

The differences between the dune areas and their immediate surroundings are not very well delineated. Of importance is the fact that the Waukegan area is a rather isolated sand region as compared with the Kankakee and Indiana Dunes which have more extensive sand dunes adjacent to them. The fact that there is less variety among the trees of the Kankakee region, that there are higher dunes and more extensive marshes at Dune Acres, and that the lake constitutes one boundry of the Waukegan and Dune Acres areas, affects the distribution of some species. The warmer, and probably drier, conditions at Kankakee, in contrast with the colder, and probably moister conditions at Waukegan—due to Lake Michigan's bordering one side of the area—undoubtedly account for some of the differences to be found in the areas.

The flora of these areas serves mainly as shelter and food for insects on which the carnivorous spiders prey. There is no evidence that spiders restrict their food to any one group of animals; they feed on those available of a suitable size (Bilsing, 1920) which do not offer too much resistance. Therefore, as far as the spiders are concerned, plants are mainly of importance as a substratum and as a control of humidity, evaporation, temperature, wind velocity, and other physical factors.

COLLECTING DATA

The methods used in collecting specimens are those usually employed in insect collecting: sifting, sweeping, beating, night collecting by shining of eyes, and simple catching of spiders as they are seen running on the ground or hanging in their webs.

The greater amount of collecting was done during the months of April through October of the years 1935 through 1941 (Table I). The collecting in the three areas was distributed as evenly as possible. The slight difference in the total number of trips probably has resulted in Waukegan's fauna having been better collected. However, on the whole, the faunas have been collected nearly equally, and, to date, there are no demonstrable differences in the collecting techniques, or trips, to account for any of the observed differences in the faunas.

Coming now to the major portion of the data (Table II), the species are listed in taxonomic order. It may be shown that these collections roughly follow Raunkiaer's Law, i.e., the species most often collected were found at all three localities, while those collected only one, two, three, or even four times, were found at only two of the localities at most. The quantitative analysis of the herb stratum, discussed later, shows this more clearly. The total number of specimens of each

species is given, as well as the number of trips on which they have been collected. However, the number of specimens probably does not give as true a picture of the abundance of species as does the number of trips on which each was collected, because some species are much easier to collect. *Geolycosa wrightii*, for example, is readily found at any of the dune areas at any time, except during the winter months. This species, however, is rather difficult to collect; ordinarily, it must be dug out of

Table I

Monthly Distribution of Trips

		WAUKEGAN	DUNE ACRES	KANKAKEE	TOTAL
Number of trips in	March	0	1	0	1
	April	4	2	1	7
	May	5	2	3	10
	June	2	3	3	8
	July	3	2	2	7
	August	5	9	4	18
	September	3	4	3	10
	October	1	1	2	4
	November	1	0	1	2
	December	0	0	0	0
	January	1	0	0	1
Total trips		25	24	19	68

the ground, a process taking from two to ten minutes. Therefore, although this species was collected on thirteen different trips, only sixty-two specimens were found. On the other hand, *Tetragnatha laboriosa* is very readily collected in a net, so that with twenty-one collections, 509 specimens were procured. On the basis of *Geolycosa,* it might be calculated that there should be about ninety specimens from twenty trips, whereas, there are almost five times as many. This proportion varies with the different species. Also, as a matter of observation and judgment, it is readily apparent to the writer, that the number of trips on which a given species was collected is a better criterion for their abundance. Later work on a more exact quantitative basis bears out this conclusion, as will be shown.

Table II

Spiders of the Chicago dune areas—Waukegan, Kankakee, Dune Acres

T—Number of trips on which each species was collected.
S—Number of specimens collected.
x—Collected in quantitative sweepings.

	Waukegan T	Waukegan S	Dune Acres T	Dune Acres S	Kankakee T	Kankakee S	Total T	Total S
I. Agelenidae—total	1	2	1	2	1	1	3	5
1. *Agelenopsis pennsylvanica* (C. L. Koch)			1	2	1	1	2	3
2. *A. potteri* (Blackwall)	1	2					1	2
II. Amaurobiidae—total	1	2	1	1	5	12	7	15
3. *Titanoeca americana* Emerton	1	2	1	1	5	12	7	15
III. Anyphaenidae—total					1	4	1	4
4. *Aysha gracilis* (Hentz)			x		1	4	1	4
IV. Argiopidae—total	32	465	41	263	35	156	108	884
5. *Acanthepeira stellata* (Walckenaer)	5	90	1	1	1	1	7	92
6. *Aranea displicata* (Hentz)	x		1	1	1	1	2	2
7. *A. foliata* Fourcroy			1	1			1	1
8. *A. thaddeus* (Hentz)			x		x			
9. *A. trifolium* (Hentz)			1	1			1	1
10. *Argiope aurantia* Lucas	2	6	4	9	2	8	8	23
11. *A. trifasciata* (Forskal)	2	8	2	4	5	10	9	22
12. *Cyclosa turbinata* (Walckenaer)			2	2			2	2
13. *Eustala anastera* (Walckenaer)	2	5	3	5	3	13	8	23
14. *Larinia borealis* Banks	2	5			1	1	3	6
15. *Leucauge venusta* (Walckenaer)			2	2	2	2	4	4
16. *Mangora gibberosa* (Hentz)			5	10	3	6	8	16
17. *M. maculata* (Keyserling)			x		1	11	1	11
18. *Meta menardii* (Latreille)			1	1			1	1
19. *Metepeira labyrinthea* (Hentz)					1	3	1	3
20. *Micrathena sagittata* (Walckenaer)			x					
21. *Neoscona arabesca* (Walckenaer)	5	38	5	11	1	1	11	50
22. *N. benjamina* (Walckenaer)			2	3	3	7	5	10
23. *N. pratensis* (Hentz)			1	1	2	12	3	13
24. *Pachygnatha xanthostoma* C. L. Koch	1	1					1	1
25. *Singa pratensis* Emerton					1	1	1	1
26. *Tetragnatha elongata* Walckenaer					1	2	1	2
27. *T. extensa* (Linnaeus)	1	1					1	1
28. *T. laboriosa* Hentz	7	301	7	131	7	77	21	509
29. *T. lacerta* Walckenaer	3	5					3	5
30. *T. pallescens* F. O. P.-Cambridge	1	4	2	6			3	10
31. *T. straminea* Emerton	1	1	1	4			2	5
V. Clubionidae—total	6	7	4	4	11	32	21	43
32. *Agroeca* sp.			x					
33. *Castianeira cingulata* (C. L. Koch)			1	1			1	1
34. *C. descripta* (Hentz)	1	1					1	1
35. *C. longipalpus* (Hentz)					1	2	1	2
36. *C. trilineata* (Hentz)			1	1	3	7	4	8
37. *Cheiracanthium inclusum* (Hentz)					2	3	2	3
38. *Clubiona obesa* Hentz	1	1					1	1
39. *C. pallens* Hentz			1	1			1	1
40. *C. riparia* L. Koch	1	2					1	2
41. *C. saltitans* Emerton					2	2	2	2
42. *Micaria aurata* (Hentz)	1	1					1	1
43. *M. montana* Emerton			1	1			1	1

	Waukegan T	Waukegan S	Dune Acres T	Dune Acres S	Kankakee T	Kankakee S	Total T	Total S
44. *Phrurolithus formica* Banks					2	16	2	16
45. *Phrurotimpus alarius* (Hentz)					1	2	1	2
46. *P. palustris* (Banks)	2	2					2	2
47. *Trachelas tranquillus* (Hentz)			x					
VI. Dictynidae—total	3	16	3	5	2	6	8	27
48. *Dictyna bostoniensis* Emerton	2	15	x				2	15
49. *D. foliacea* (Hentz)			1	1			1	1
50. *D. frondea* Emerton	x		2	4	1	5	3	9
51. *D. volucripes* Keyserling	1	1	x		1	1	2	2
VII. Dysderidae—total					1	1	1	1
52. *Dysdera crocata* C. L. Koch					1	1	1	1
VIII. Gnaphosidae—total	5	7	9	12	19	27	33	46
53. *Callilepis imbecilla* (Keyserling)			2	2	6	12	8	14
54. *Cesonia bilineata* (Hentz)	x							
55. *Drassodes neglectus* (Keyserling)	1	1	2	2	1	3	4	6
56. *D. robinsoni* Chamberlin	1	2			2	2	3	4
57. *Drassylus depressus* (Emerton)					1	1	1	1
58. *Gnaphosa sericata* (C. L. Koch)					1	1	1	1
59. *Haplodrassus signifer* (C. L. Koch)			1	1	1	1	2	2
60. *Herpyllus vasifer* (Walckenaer)	2	3	3	6	3	3	8	12
61. *Poecilochroa montana* Emerton					2	2	2	2
62. *Sosticus insularis* (Banks)			1	1			1	1
63. *Zelotes subterraneus* (C. L. Koch)	1	1			2	2	3	3
IX. Hahniidae—total	1	1					1	1
64. *Neoantistea agilis* (Keyserling)	1	1					1	1
X. Linyphiidae—total	1	1	2	3	3	3	6	7
65. *Bathyphantes formica* Emerton	x		x		1	1	1	1
66. *B. nigrinus* (Westring)	1	1	1	2			2	3
67. *Frontinella coccinea* (Hentz)					1	1	1	1
68. *F. communis* (Hentz)					x			
69. *Linyphia marginata* C. L. Koch					1	1	1	1
70. *L. pusilla* Sundevall			x					
71. *Pityohyphantes phrygiana* (C. L. Koch)			1	1			1	1
XI. Lycosidae—total	48	116	28	110	37	130	113	356
72. *Arctosa emertoni* Gertsch	2	2					2	2
73. *A. littoralis* (Hentz)	6	30	3	21	2	4	11	55
74. *Geolycosa missouriensis* (Banks)	3	6	1	1	4	19	8	26
75. *G. wrightii* Emerton	6	15	5	43	2	4	13	62
76. *Lycosa aspersa* Hentz			1	1			1	1
77. *L. avara* (Keyserling)			1	1	4	5	5	6
78. *L. avida* Walckenaer	6	13	2	8	4	41	12	62
79. *L. baltimoriana* (Keyserling)	1	4	2	3	6	15	9	22
80. *L. carolinensis* Walckenaer					1	1	1	1
81. *L. expulsa* Gertsch and Mulaik					2	3	2	3
82. *L. frondicola* Emerton	1	1	2	2	3	4	6	7
83. *L. helluo* Walckenaer	3	5	1	2	1	1	5	8
84. *L. rabida* Walckenaer			3	4	1	1	4	5
85. *Pardosa fuscula* (Thorell)			1	1			1	1
86. *P. milvina* (Hentz)	6	25	2	15	3	24	11	64
87. *P. modica* (Blackwall)	2	2					2	2
88. *P. moesta* Banks	1	1	x				1	1
89. *P. saxatilis* (Hentz)	2	2					2	2
90. *Pirata insularis* Emerton	2	3					2	3
91. *P. montanus* Emerton	1	1					1	1
92. *P. piratica* (Olivier)	3	3	1	4	1	1	5	8

Table II, continued next page

	Waukegan T	Waukegan S	Dune Acres T	Dune Acres S	Kankakee T	Kankakee S	Total T	Total S
93. *Schizocosa bilineata* (Emerton)	2	2					2	2
94. *S. crassipes* (Walckenaer)			1	1			1	1
95. *S. retrorsa* (Banks)	1	1					1	1
96. *S. saltatrix* (Hentz)			2	3	3	7	5	10
XII. Micryphantidae—total	4	6	7	13	1	1	12	20
97. *Ceraticelus emertoni* (O. P.-Cambridge)	x		1	1	x		1	1
98. *C. fissiceps* (O. P.-Cambridge)			1	1			1	1
99. *C. similis* (Banks)	1	1					1	1
100. *Ceratinopsis anglicana* (Hentz)			1	1			1	1
101. *Eperigone contorta* (Emerton)			1	1			1	1
102. *Erigone atra* Blackwall	1	3					1	3
103. *E. autumnalis* Emerton			1	1	1	1	2	2
104. *E. dentigera* (O. P.-Cambridge)			1	1			1	1
105. *Hypselistes florens* (O. P.-Cambridge)			1	7			1	7
106. *Minyriolus arenarius* (Emerton)	1	1					1	1
107. *Oedothorax bidentatus* (Emerton)	1	1					1	1
XIII. Mimetidae—total			1	1	2	2	3	3
108. *Mimetus interfector* Hentz			1	1	2	2	3	3
XIV. Oxyopidae—total	3	8	2	2	5	26	10	36
109. *Oxyopes salticus* Hentz	3	8	2	2	5	26	10	36
XV. Pisauridae—total	5	7	9	9	2	5	16	21
110. *Dolomedes scriptus* Hentz			1	1			1	1
111. *D. striatus* Giebel			1	1	1	1	2	2
112. *D. tenebrosus* Hentz			3	3			3	3
113. *D. triton sexpunctatus* Hentz	2	3	2	2	1	4	5	9
114. *Pisaurina brevipes* (Emerton)	1	1					1	1
115. *P. mira* (Walckenaer)	2	3	2	2			4	5
XVI. Salticidae—total	44	300	25	44	45	157	114	501
116. *Admestina tibialis* (C. L. Koch)					1	1	1	1
117. *Evarcha hoyi* (Peckham)			x					
118. *Habrocestum pulex* (Hentz)					1	1	1	1
119. *Hentzia mitrata* (Hentz)			1	1			1	1
120. *H. palmarum* (Hentz)			1	1			1	1
121. *Hyctia pikei* Peckham	x							
122. *Icius elegans* Hentz			1	1	1	1	2	2
123. *I. hartii* Emerton	1	1			1	1	2	2
124. *I. similis* Banks					1	1	1	1
125. *Maevia vittata* (Hentz)	x		2	4	10	48	12	52
126. *Metaphidippus capitatus* (Hentz)	4	44	3	7	3	7	10	58
127. *M. flavus* (Peckham)	6	34	1	1			7	35
128. *Paraphidippus marginatus* (Walckenaer)	6	16	2	4	2	2	10	22
129. *Peckhamia scorpionea* (Hentz)	1	1			x		1	1
130. *Pellenes agilis* (Banks)	5	78	3	3	4	15	12	96
131. *P. arizoniensis* Banks					1	1	1	1
132. *P. borealis* (Banks)	4	11	1	1			5	12
133. *P. calcaratus* Banks			x		x			
134. *P.*, sp. nov.			x		1	1	1	1
135. *P. viridipes* (Hentz)	2	6			1	2	3	8
136. *Phidippus audax* (Hentz)	2	3	4	4	3	8	9	15
137. *P. brunneus* Emerton	5	31	1	3	2	2	8	36
138. *P. clarus* Keyserling	3	35	3	11	1	1	7	47
139. *P. insignarius* (C. L. Koch)	2	27	x		7	59	9	86
140. *P. mccooki* (Peckam)	x		x					
141. *P. whitmanii* Peckham					3	5	3	5
142. *Sidusa borealis* Banks					x			
143. *Sittacus palustris* (Peckham)	1	11	1	2			2	13

	WAUKEGAN T	S	DUNE ACRES T	S	KANKAKEE T	S	TOTAL T	S
144. *Zygoballus bettini* Peckham			1	1	1	1	2	2
145. *Z. nervosus* (Peckham)	2	2					2	2
XVII. Theridiidae—total	8	14	4	5	8	19	20	38
146. *Enoplognatha marmorata* (Hentz)					2	8	2	8
147. *Euryopis funebris* (Hentz)	1	1					1	1
148. *Latrodectus mactans* (Fabricius)			x		2	5	2	5
149. *Lithyphantes albomaculatus* (DeGeer)	3	5	1	1	4	6	8	12
150. *Steatoda borealis* (Hentz)	1	5					1	5
151. *Theridion differens* Emerton	x		2	3			2	3
152. *T. frondeum* Hentz			x					
153. *T. murarium* Emerton	2	2	1	1			3	3
154. *T. tepidariorum* C. L. Koch	1	1					1	1
XVIII. Thomisidae—total	33	238	29	49	26	102	88	389
155. *Coriarachne versicolor* Keyserling			2	2	x		2	2
156. *Ebo latithorax* Keyserling			1	1			1	1
157. *E. pepinensis* Gertsch	1	2					1	2
158. *Misumenoides aleatorius* (Hentz)	3	29	5	7	1	2	9	38
159. *Misumenops asperatus* (Hentz)	x		2	2	6	43	8	45
160. *M. celer* (Hentz)	2	3					2	3
161. *M. oblongus* (Keyserling)	1	1	3	7	1	2	5	10
162. *Philodromus alascensis* Keyserling	3	11	x				3	11
163. *P. aureolus* (Olivier)	4	63	3	3			7	66
164. *P. imbecillus* Keyserling			1	1			1	1
165. *P. infuscatus* Keyserling					1	1	1	1
166. *P. pernix* Blackwall	4	12	2	2	2	2	8	16
167. *P. rufus* Walckenaer			1	4			1	4
168. *P. thorelli* Marx			1	3			1	3
169. *Thanatus* sp.	2	2	x		2	6	4	8
170. *Tibellus duttoni* (Hentz)					1	1	1	1
171. *T. maritimus* (Menge)	1	1	x				1	1
172. *T. oblongus* (Walckenaer)	4	45	3	4	1	3	8	52
173. *Tmarus angulatus* (Walckenaer)			1	1			1	1
174. *Xysticus banksi* Bryant	2	3					2	3
175. *X. elegans* Keyserling					3	8	3	8
176. *X. ferox* (Hentz)					2	3	2	3
177. *X. fraternus* Banks	x		1	1	x		1	1
178. *X. gulosus* Keyserling	2	56	2	8	2	18	6	82
179. *X. luctans* (C. L. Koch)	2	4			1	1	3	5
180. *X. triguttatus* Keyserling	2	6	1	3	2	11	5	20
Total web-builders	51	507	60	293	57	200	168	1000
Total non-web-builders	144	683	106	230	147	484	397	1397
Grand total	195	1190	166	523	204	684	565	2397
Percent of non-web-builders according to trips	73.8		63.8		72.0		70.2	
Number of specimens in general and quantitative collecting	2056		2097		1028		5181	
Number of species	96		114		101		180	

CHARACTERISTICS OF SPIDERS OF DRY, OPEN LANDS AS ILLUSTRATED BY BLACK OAK SPECIES

Probably the most important factors in the distribution of spiders are substratum and humidity. The substratum of the ground floor species, such as the lycosids, is restricted only slightly (lakes and other water-covered areas are the main limiting factors). Web-building species must have grasses, bushes or trees on which to build their ensnaring webs. Table III is arranged with all the web-building species together; the first thirteen families listed are those which build largely in the open, hanging their webs from trees, shrubs and grasses. In comparing these web-building species with the non-web-building species, we find that, in the entire Chicago area, 58 per cent of the spiders are non-web-builders, whereas, in the dune areas, nearly two-thirds of the species (65 per cent) are vagabonds (free-running). This difference is not as great as it might be, since many of the web-builders are small species requiring only a leaf or a small bush on which to build their webs. Therefore, they are actually in the category of the vagabond species which require little more in the way of substratum than a solid surface on which to walk.

It may be seen from the list of spiders of surrounding states, that an even smaller percentage are free-running, ranging from 46 to 52 per cent with the average being 49 per cent. These percentages vary so little, that it would seem they must be approximately correct, as the collecting was done by four different persons (Elliott, Barrows, Chickering, Field). There are many rare species which have not yet been collected; however, they are less important in one respect: they are not the dominant spider species, though some of them may be more characteristic of the dry, open areas.

The question may be raised as to why the non-web-builders of the Chicago area are better represented in the collection of the writer than in the lists of the surrounding states which have much the same types of habitats. This may be explained by the fact that about half of the Chicago region collecting has been done in the dune areas, while about a quarter of the time was spent in the more mesic forests where those species which build webs are more common. Therefore, many of the rare non-web-builders have been collected but not as many of the rare web-builders. It is to be expected that, as collecting is continued in the more densely wooded areas about Chicago, the rare species will be added. These probably will be web-builders more often than non-web-builders, so that the proportion of free-running, non-web-builders to the total number will become lower and approach the 49 per cent level of surrounding

states. Nevertheless, it is still significant that there are two times (121/63) as many species of web-builders in the Chicago area as there are in the dunes; in contrast, there are only 1.41 (168/118) as many species of non-web-builders.

Table III

Distribution of Species of Spiders by Families in Various States of the North-Central United States

Each number represents the number of species in the particular categories concerned.

Family	DUNES Lowrie	CHICAGO AREA Lowrie	BEECH-MAPLE Elliott	INDIANA Elliott	MICHIGAN Chickering	WISCONSIN Field	OHIO Barrows
1. Agelenidae	2	12	8	10	12	8	10
2. Amaurobiidae	1	3	2	2	4	3	4
3. Argiopidae	27	42	13	40	53	41	44
4. Atypidae	0	1	0	1	0	0	2
5. Dictynidae	4	8	5	6	6	6	10
6. Hahniidae	1	3	3	3	2	2	2
7. Linyphiidae	7	12	8	16	29	17	31
8. Micryphantidae	11	16	11	15	17	9	24
9. Mimetidae	1	3	1	2	2	2	1
10. Pholcidae	0	1	0	1	1	2	2
11. Sicariidae	0	0	0	1	1	0	0
12. Theridiidae	9	18	8	18	26	23	24
13. Uloboridae	0	2	2	2	2	2	2
Total web-builders	63	121	61	117	155	115	156
14. Anyphaenidae	1	5	2	3	3	3	4
15. Clubionidae	16	22	8	14	24	16	20
16. Ctenidae	0	0	0	1	0	0	0
17. Dysderidae	1	1	1	1	0	0	1
18. Gnaphosidae	11	15	4	3	15	13	13
19. Lycosidae	25	33	5	22	31	28	29
20. Oecobiidae	0	1	0	0	1	0	0
21. Oxyopidae	1	1	0	1	1	1	1
22. Pisauridae	6	8	2	5	6	5	5
23. Salticidae	30	42	8	28	34	30	45
24. Thomisidae	26	40	8	23	31	27	30
Total non-web-builders	117	168	38	101	146	123	150
Total species	180	289	99	218	301	238	306
Percent of non-web-builders	65	58	38	46	49	52	49

In Table II it is seen that the most common families are the Argiopidae, Salticidae, Thomisidae, and Lycosidae. A comparison of the web-builders and non-web-builders reveals that the latter is the dominant group. For reasons presented above, it seems best to use the total number of trips on which all of the species were collected, in such a comparison, rather than the total number of specimens collected. Considering these percentages, it is apparent that the non-web-builders are still more common than in the previous tabulation of species. In other words, there are not only more species of non-web-builders in the dune areas, but there are also proportionately more individuals as indicated by the number of times they have been collected. Again it might be emphasized that this percentage would be even higher if the amaurobiids, dictynids, hahniids, and micryphantids were included in the vagabond spider grouping, a grouping which would then include the species not requiring any substantial spatial substratum on which to build webs.

Experiments to prove the relative importance of the substratum and of humidity have not been directly made in this study. However, of interest in this regard is a comparison of the spiders of the black oak dunes with those of a beech-maple forest as analyzed by Elliott (1930). Here the reverse condition is to be found; only 38 per cent of the species are non-web-builders. Humidity is greatly increased over that of the drier, black oak dunes, but as Shelford (1913) has noted, the herb-shrub zone in the climax forest is not very extensive; it is no greater, probably, than that of the black oak dunes. Therefore, it would seem probable in this instance, that the humidity is the limiting factor more than is the substratum. In some cases, however, humidity is of lesser importance as is shown by the black widow which may be raised entirely without water except for what is received from the prey and from the air—which is about equal, in a steam-heated building, to that of the Sahara Desert. For them, a substratum on which to build a web to catch food is of more importance. Specimens confined to the laboratory, where their webs may be readily destroyed, perish, although insects may be crawling all about them. Most spiders, on the other hand, need much more water, and some, such as *Dolomedes urinator*, will die if left without water for as short a period as four hours. Therefore, it should be concluded that each species must be considered individually, though, on the whole, humidity is probably a limiting factor for more species than is the substratum, since fewer species are web-builders requiring a special substratum.

The movement of air, as well as the temperature, is of importance in relation to the moisture content of the air; i.e., the more wind and heat, the less moisture and the greater the rate of evaporation. Thus, all

these factors are interrelated, as there is more effect of wind and heat when there are fewer intercepting trees and shrubs. The mechanical effect of strong winds is also of importance. The fragile spider webs built on grasses, shrubs and trees are easily destroyed by wind. The wind also is of importance in distributing the spiders to other dry, open lands. This phenomenon of distribution is not only operative in the dunes but takes place anywhere, as it is characteristic of many spiders. In the spring and fall these spiders are dispersed by means of a long, trailing thread of silk which is buoyant enough to carry them off like a balloon (Emerton, 1908). Thus, this order has a means of dispersal excelled only by the actively flying animals and even exceeding some of them in the ubiquity of their dispersal; i.e., their passive flight distributes them to places they might never attempt to reach if they were actively able to control their flight. Due to their passivity, they are carried over water and mountains which would be barriers for many flyers. They have been found in the air at altitudes of 15,000 feet (Glick, 1939) and several hundred miles at sea (Comstock, 1940; Bristowe, 1939).

The temperature is a limiting factor, for many spiders cannot withstand the effect of the heat itself. Midday heat eliminates much activity, as the soil temperatures reach 40° C. to 60° C. (Strohecker, 1937a) at the surface in this sparse oak association. Therefore, during much of the day, the heat is too great for activity. Two attempts to ascertain the limiting effects of temperature were made on the foredune and beach at Dune Acres with the sand spider, *Arctosa littoralis*. On July 20, 1941, the sand temperature was 43° C. One specimen, released in an area ten feet square, was retained in the area by being pushed back with a stick whenever an attempt was made to leave. After three initial attempts to leave the area, the spider remained for fifteen minutes without moving. After two more attempts, it remained quiet for ten minutes, when the experiment was discontinued. On August 3, 1941 two more *A. littoralis* and three *Geolycosa wrightii* were released on the beach where the temperature of the surface sand was 45° C. These spiders also showed little movement and survived a half hour's exposure without any apparent ill effects. This was probably due to their long legs which keep their bodies from close contact with the hot sand. Chapman *et. al.* (1926), has shown that mutillids and most other sand insects can withstand temperatures up to 50° C. if their bodies are kept from contacting the hot surface. Therefore, it is apparent that the upper limit of tolerance for these spiders had not been reached. Carefully controlled laboratory experiments are indicated as a more accurate means of solving the problem of heat tolerance in these animals.

Table IV

Abundance of the Common Species

T—Number of trips on which species was collected.

S—Number of specimens collected.

BO—Number of 100-sweep units in the herbaceous layer of the black oak dunes of the three areas in which the species was collected.

WDK—Number of 100-sweep units in the herbaceous layer of all types of habitats of the three areas in which the species was collected.

An arbitrary limit of abundance as considered here is the species which were collected in more than three 100-sweep units and on more than three trips.

Species	T	S	BO	WDK
1. *Tetragnatha laboriosa*	21	509	34	60
2. *Geolycosa wrightii*	13	62	0	0
3. *Pellenes agilis*	12	96	29	37
4. *Lycosa avida*	12	62	0	0
5. *Maevia vittata*	12	52	36	41
6. *Pardosa milvina*	11	64	0	0
7. *Arctosa littoralis*	11	55	0	0
8. *Neoscona arabesca*	11	50	24	48
9. *Metaphidippus capitatus*	10	58	18	28
10. *Oxyopes salticus*	10	36	8	8
11. *Paraphidippus marginatus*	10	22	0	2
12. *Phidippus insignarius*	9	86	33	49
13. *Misumenoides aleatorius*	9	38	10	12
14. *Argiope trifasciata*	9	22	13	21
15. *Lycosa baltimoriana*	9	22	0	0
16. *Phidippus audax*	9	15	0	2
17. *Mangora gibberosa*	8	86	19	19
18. *Tibellus oblongus*	8	52	2	7
19. *Misumenops asperatus*	8	45	42	49
20. *Phidippus brunneus*	8	36	3	11
21. *Geolycosa missouriensis*	8	26	0	0
22. *Argiope aurantia*	8	23	2	7
23. *Eustala anastera*	8	23	9	12
24. *Philodromus pernix*	8	16	4	6
25. *Callilepis imbecilla*	8	14	0	0
26. *Herpyllus vasifer*	8	12	0	0
27. *Lithyphantes corollatus*	8	12	0	0
28. *Acanthepeira stellata*	7	92	0	7
29. *Philodromus aureolus*	7	66	18	21
30. *Phidippus clarus*	7	47	8	19
31. *Metaphidippus flavus*	7	35	0	0
32. *Titanoeca americana*	7	15	0	0
33. *Xysticus gulosus*	6	82	9	15
34. *Lycosa frondicola*	6	7	0	0
35. *Xysticus triguttatus*	5	20	1	2
36. *Pellenes borealis*	5	12	0	7
37. *Neoscona benjamina*	5	10	0	0
38. *Schizocosa saltatrix*	5	10	0	0
39. *Misumenops oblongus*	5	10	0	0
40. *Dolomedes t. sexpunctatus*	5	9	0	0
41. *Lycosa helluo*	5	8	0	0
42. *Pirata piratica*	5	8	0	0
43. *Lycosa avara*	5	6	0	0
44. *Castianeira trilineata*	4	8	0	0

Species	T	S	BO	WDK
45. *Thanatus* sp.	4	8	1	1
46. *Drassodes neglectus*	4	6	0	0
47. *Lycosa rabida*	4	5	1	4
48. *Pisaurina mira*	4	5	2	6
49. *Leucauge venusta*	4	4	5	5
50. *Neoscona pratensis*	3	13	0	3
51. *Philodromus alascensis*	3	11	0	10
52. *Tetragnatha pallescens*	3	10	0	0
53. *Dictyna frondea*	3	9	9	9
54. *Pellenes viridipes*	3	8	0	0
55. *Xysticus elegans*	3	8	1	1
56. *Larinia borealis*	3	6	0	0
57. *Tetragnatha lacerta*	3	5	0	0
58. *Phidippus whitmanii*	3	5	0	0
59. *Xysticus luctans*	3	5	0	0
60. *Drassodes robinsoni*	3	4	0	0
61. *Zelotes subterraneus*	3	3	0	0
62. *Mimetus interfector*	3	3	0	0
63. *Dolomedes tenebrosus*	3	3	0	0
64. *Theridion murarium*	3	3	1	1
65. *Xysticus fraternus*	1	1	32	37
66. *Ceraticelus emertoni*	1	1	21	26
67. *Theridion differens*	2	3	14	15
68. *Clubiona* sp.	0	0	12	27
69. *Pellenes calcaratus*	0	0	9	9
70. *Hentzia mitrata*	1	1	7	9
71. *Icius elegans*	2	2	6	6
72. *Xysticus banksi*	2	3	5	8
73. *Aranea thaddeus*	0	0	5	7
74. *Aysha gracilis*	1	4	3	5
75. *Theridion frondeum*	0	0	3	5
76. *Aranea displicata*	2	2	3	4

Light, which is associated with temperature, is of importance in connection with the sense of sight. The free-running spiders, which have better sight than the web-builders (Peckham, 1894), have been shown to predominate here in the dry, open lands. Another phase of the light factor is the theory of protective coloration. Several spiders, *Geolycosa wrightii*, *Arctosa littoralis*, *Philodromus alascensis*, and *Pellenes borealis*, to mention only the more outstanding, are grayish mottled, resembling the sand to a marked degree. This question, however, is one which is not analyzed here, though contributions to the theory may be made by studies of the dune spiders.

The relative abundance of species is shown in Table IV. Columns one and two include species collected on three or more trips into the field. Columns three and four include species collected in the study of the herb

stratum in order of their abundance as found in the black oak dunes and at the three dune areas in various habitats. The four columns are seen to be in general agreement if the lycosids and gnaphosids, which are ground forms, are not considered. Many of these common species are ubiquitous and apparently able to withstand the rather rigorous conditions of the dunes by being inactive during the day. At the opposite extreme are such species as *Micrathena sagittata* and *Tetragnatha elongata*, which probably always will be rare in dry, open areas, as their usual habitat is a very humid area (Comstock, 1940; Emerton, 1902). Their presence here is correlated with the nearby marshy areas and the few mesic pockets at Dune Acres from which they have come. A few of these species, such as *Lycosa helluo* and *Dolomedes t. sexpunctatus*, are common to the three areas but are not characteristic or numerous. They seem to be found only in or near the moist marshy areas.

The characteristic common species of these dune areas are the following. *Arctosa littoralis* is a sand species, largely restricted to the margins of rivers and lakes (Gertsch, 1934). It has probably persisted in the Kankakee region, due to the former presence of the river marshes in this area. *Geolycosa wrightii* and *G. missouriensis* are also sand inhabitants, the latter burrowing in less sandy soil, according to field observations. *Lycosa baltimoriana* also seems to be a sand dweller, as it has been collected only in sandy areas in the Chicago region. Possibly some of the common thomisids are also characteristic of sandy areas. However, none of them seems to be restricted to these areas; rather they are restricted to flowers, tree trunks and other more widespread vegetation.

Pardosa milvina, *Phidippus audax*, *Philodromus pernix*, *Herpyllus vasifer*, *Acanthepeira stellata*, *Dolomedes t. sexpunctatus*, *Pirata piratica*, *Castianeira trilineata*, *Lycosa rabida*, *L. helluo.* and *Leucauge venusta* of the first fifty species of Table IV are much more frequently found in moist areas (Comstock, 1940). They have been collected near the marshes of the dunes and cannot be called typical dry, open land species. From the habitats in which they have been collected (Comstock, 1940; Emerton, 1902) it would appear that the remaining common species are probably more typical of dry, open lands. They do not necessarily require a sandy soil. Many of the common species are also prairie forms, probably due to the fact that the land is open and prairie-like in its abundance of grasses.

In the fauna of any given type of habitat, certain characteristics become evident. In dry, open lands, the fauna is, in general, characterized by having a predominance of flocking, burrowing, cursorial, nocturnal, and drought-resisting or drought-evading forms (Hesse, Allee and Schmidt, 1937). The spiders show all of these types to a certain

extent, though, probably because cannibalism prevents such social behavior, the flocking forms are practically non-existent in the usual sense of the word. The only "herds" of spiders in the temperate regions are to be found in aggregations due to the proximity of the habitat niches, a familial feeding arrangement, or hibernation. For example, *Titanoeca americana* and other log-inhabiting forms will be found in groups, as they are restricted to living in logs where they thus form an apparently social arrangement. Another type af aggregation is to be found among members of the species *Pisaurina mira*, many of the lycosids and some of the theridiids in which the female remains with the young for a week or two after they emerge from the cocoon. At this time, the aggregation functions for food-getting as well, because the young feed upon each other, as other suitable food is not usually available in large enough quantities. Hibernation also calls forth a pseudo-flocking habit as illustrated by *Phrurolithus formica* and *Philodromus pernix*, which have been found in close groups of a dozen or more during the winter months. This aggregating habit occurs as the temperature lowers and is probably of survival value when the temperature reaches a lethal low point (Allee, 1931, p. 70; Holmquist, 1926). However, none of these aggregations may be considered as true flocks.

The other characteristics of animals of dry, open lands are well illustrated by the spiders. The burrowing habit is rather characteristic of species which evade the full impact of the environment. That is, these species burrow into the ground and remain in their burrows during the day, when the heat and drying conditions are at their maximum. They come out to hunt and carry on their main activities at night when the moisture and coolness are at their maximum. Such species are *Dysdera crocata*, *Geolycosa missouriensis*, *G. wrightii*, *Lycosa baltimoriana*, and *L. helluo*. Although these are few, they are the entire complement of burrowers which have been found in the Chicago area. Many other species, such as *Arctosa littoralis* and most of the other lycosids and gnaphosids, pass the day beneath bark, leaves and other material on the ground. Upon passing through these dune areas during the day, one may see scarcely any spiders without lifting floor debris or the bark of dead trees; even the web-builders are not in their snares but in their protected retreats. On the other hand, in a deep mesic woods, one may find many of the species at least slightly active during the day.

Cursorial forms are also in the majority as shown previously in comparing the web-builders and non-web-builders. Most of the non-web-builders are cursorial forms. The lycosids and salticids in particular

are well-known for their roving tendencies. Sight, too, is of very great importance among desert animals. This again is one of the attributes of the free-running forms. The salticids, oxyopids, and lycosids have particularly keen sight (Peckham, 1894) and, as has been shown, are among the dominant spiders in the dunes. In dry, open lands the limiting physical factors are more often expressed at night. In other words, many animals of the deserts cannot withstand the physical environment of the day except by passing the time in hiding. Thus, the day humidity and heat will not limit many species which can find niches where they may avoid the environment of the day. This is probably one of the factors which developed the burrowing habit and speed of movement. Mosauer (1936) has shown that desert reptiles cannot live exposed to the desert sun, where temperatures rise only a few degrees higher than in the black oak dunes. Therefore, they must avoid the heat by running from bush to bush or by remaining inactive in the shade. The spiders seem to be preadapted to this type of life, as most of them are nocturnal (Comstock, 1940); they can more readily invade such a habitat as dry, open lands, where an animal must either be able to resist diurnal conditions or hide from them and become nocturnal.

It is apparent that spiders of the dry, open lands, as shown in this study, are essentially similar to other animals in that the cursorial, burrowing, nocturnal types are dominant. In particular, there is a reduction in the number of web-builders, due to the lack of substratum, lack of moisture, high temperatures and other environmental conditions.

A COMPARISON OF THE SPIDER FAUNAS OF THE DUNE AREAS

One of the obvious differences between the faunas of the three areas studied is the small number of species found at Waukegan. This may be due in part to the lack of simlar dune areas adjacent to Waukegan, to the more northern location and to the direction of the prevailing winds. The dune area at Waukegan was studied in its entirety and there is no similar dune area nearby from which dune species could invade the Waukegan flats. The Kankakee and Dune Acres areas, in contrast, are only parts of larger dune complexes. Species from these surrounding dunes could easily enter into the small areas which were studied.

The wind as a factor in distribution of dune spiders has been mentioned. Of great importance is the direction of the wind. In the Chicago area, it is prevailingly from the southwest (Cox, 1914). In terms of the dune areas, the wind direction is from Kankakee to Dune Acres the

greater part of the time, from Kankakee to Waukegan and from Dune Acres to Waukegan scarcely at all. This would affect the dispersal of the spider fauna. Of the 180 species in the areas, 43 were collected in all three and 92 in only one (31-Waukegan, 33-Dune Acres, 28-Kankakee). Of the remaining 45 species twenty-three are common to Dune Acres and Kankakee, seven to Kankakee and Waukegan, and fifteen to Waukegan and Dune Acres. This order, it will be seen, is similar to the effectiveness of the wind in dispersal; the two areas in the southwest-northeast line (Dune Acres and Kankakee) have twice as many species in common as do the other areas which are not in line with the usual winds. The small number of species common to both Kankakee and Waukegan would seem to indicate that the distance is also a factor, as these two areas are farthest apart. Of course, it must not be overlooked that there are some sand areas west of the Great Lakes from which Waukegan could receive additions. However, none is nearer than the Mississippi River, and the Waukegan area is comparatively small. It would thus be likely to receive only a few of those specimens carried by the wind.

Possibly of more general importance is the matter of temperature relations. It is well known that the east shore of the lake is warmer throughout the year than is the west shore, so that an area farther north on the east shore will be as warm as a place one hundred or more miles south of that latitude on the west shore. The isotherms run approximately parallel with a line from the vicinity of St. Joseph, Michigan to downtown Chicago (Cox, 1914). Thus, of the three areas, Waukegan is coldest. This agrees with the fact that there are fewer species at Waukegan. The factor of temperature may be of prime importance also because spiders are cold-blooded animals and, as such, are much more restricted by cold than are warm-blooded species. Just how the temperature affects spiders is not too apparent, but there are many possibilities, and the problem will be settled only when the geographic ranges are better known, and the various effects of temperature more clearly indicated. However, the distribution of some species is known. Most of these are widespread and present in all three areas. A few, seem to be more abundant in the southern United States. Two of these, *Schizocosa saltatrix* and *Latrodectus mactans,* are lacking and one, *Oxyopes salticus,* is rare at Waukegan. None of these seems to be a truly northern species, so this would indicate that southern species are more common at Kankakee and do not readily establish themselves at Waukegan.

Among other animals studied, species of termites of the genus *Reticulitermes* (Emerson—personal communication), the blue racer,

Coluber c. flaviventris and the six-lined race-runner, *Cnemidophorus sexlineatus* (Schmidt and Necker, 1935) are conspicuous by their absence from the Waukegan Dunes. Although these animals may be found in the future, they will probably be rare. As these are more common in the South, it would indicate that temperature is of prime importance.

The species common to Kankakee and Dune Acres, but not found at Waukegan, are indicative of a closer connection between these areas. Those found only in one locality are of little value for comparison, because collecting has not been complete; in the future, they, as well as many found at present in two localities, may be found in all three of the areas. Many of these species may be only accidentally present. Those found at two localities may give better indications of specific differences. *Maevia vittata*, *Mangora gibberosa*, *Latrodectus mactans*, *Leucauge venusta*, *Neoscona benjamina*, and *Neoscona pratensis* have been collected in sufficient quantities and often enough that their absence from Waukegan may not be explained on the basis of their rarity. The reason may be only surmised. As indicated above, the more northern location of Waukegan, and the southern range of some of the species, may be the answer.

Philodromus alascensis, *Metaphidippus flavus*, and *Philodromus aureolus* have been found only at Waukegan and Dune Acres. One reason for this is the absence of beach grasses (*Ammophila* and *Calamovilfa*) at Kankakee. Both grasses are common on the foredunes of the two lakeside regions. *Philodromus alascensis* in particular would be affected, as it is most common in silken nests in the spikes of *Ammophila arenaria* which is rare or entirely lacking elsewhere (Pepoon). The two species of *Geolycosa* show another interesting distribution. *G. missouriensis* has been found more often in areas where the sand has some humus mixed with it and where there is some vegetation. *G. wrightii*, on the other hand, seems to be common on sparsely plant-covered beach, foredune, cottonwood dune, or blowout where humus in the soil is at a minimum. This apparent habitat preference shows in its relative abundance at the three areas (Table II). *G. missouriensis* has been collected more often at Kankakee where there is relatively little pure sand, while *G. wrightii* is more common in the lakeside dunes. *Arctosa littoralis* shows the same distribution as *G. wrightii*. It has been collected only twice at Kankakee (4 specimens) in contrast with nine times at the other areas (51 specimens). This spider is found commonly on the beach where it feeds to a great extent on drift line insects. *Lycosa baltimoriana*, like *G. missouriensis*, seems to frequent the areas with more humus, as it is never found on the beach and is more common at Kankakee.

QUANTITATIVE ANALYSIS OF THE HERB STRATUM

After the material presented above had been accumulated, it seemed desirable to have some accurate information as to relative abundance of the species at the three areas. Quadrat studies were considered and attempted, but due to the sparseness of the population it was apparent that a large quadrat would be necessary; such a quadrat, of the magnitude of ten to fifteen feet square, would necessitate the aid of another person. As this was not possible at the time, it seemed advisable to attempt some other form of analysis. Sweeping of the vegetation in the herb stratum was decided upon as being a practical solution. Beall (1935) and other workers have shown that uniform sweeping can give a good index of insects and other members of the herbaceous stratum population. Therefore, during August of 1940, and May through October of 1941, sweeping of the herbaceous layer was carried out at the three dune areas.

The ideal comparison would be to make a definite number of sweeps at each of the three areas simultaneously. This was, of course, impossible. However, sweeping a certain number of times at each area on successive days would be almost as satisfactory. Therefore, six separate collecting trips were made as follows: three successive days (August 14, 15, 16, 1940) were spent at Dune Acres, Kankakee, and Waukegan respectively; three days more (August 28, 29, 30, 1940) were spent at Waukegan, Kankakee, and Dune Acres respectively. At each area, on each visit, four sets of 100 approximately equal ten-foot sweeps were made with a heavy sweeping net. The use of one hundred sweeps as a unit was merely an arbitrary one of most convenience. More sweeps would result in greater accuracy. However, a larger number would involve too much additional debris in the net to make it possible to collect the spiders completely and, in a few instances, less than one hundred sweeps would have been slightly more desirable. In all, 2400 ten-foot sweeps yielded 675 specimens, an average of one spider every 3.55 sweeps. Each of the twelve sets of sweepings on each trip was made at slightly different areas to give, as nearly as possible, an unbiased cross section of the population. At Dune Acres sweepings were made on the foredune, in a mesophytic pocket of jack pine (*Pinus banksiana*), sassafras, ferns, may apples, etc., in a swampy lowland peat meadow, and at various spots on the black oak dunes proper. At Kankakee sweepings were made on the crests of the dunes, on the slopes, and in the lowlands which were quite dry at this season in comparison with their springtime condition and in contrast with similar areas at the other dunes. The plants are largely herbaceous with some black oak and willow. Sweeping

at Waukegan was carried on in a swampy inland area, at several places in the black oak dunes, and lower interdunal swales, in the heath-like area of creeping juniper, poison ivy, low grasses, grape vines, willow and prickly pear cactus near the beach and on the foredunes. Collections of the first three days were carried on in the mornings and early afternoons, while on the next three days collecting was done in the late afternoons, except for the last collection at Dune Acres, which was made in the morning. Previous to each of the last three collections, there had been rain, while the first three collections were made during weather of over 80° F. (27° C.) with no rain or clouds. Therefore, the physical factors were as nearly similar as could be expected during each series of collections. The rainy weather, as well as the lateness of the season, probably accounts for the smaller number (245) of specimens collected on the second three days in contrast with almost twice as many (431) on the first three days.

From the number of specimens (Table V) it may be seen that there are 76.7 percent non-web-builders in contrast with one-third as many web-builders. This substantiates quite well the data as analyzed in Table III, where it is found that 38 percent of climax beech-maple spiders and 50 percent of the species of Michigan, Indiana, Ohio and Wisconsin are non-web-builders, while 65 percent of the species of dune spiders build no webs. Using the number of specimens instead of the number of species, there is a rise to 76.7 percent. Probably this would increase, as indicated in Table II, if a technique could be devised for including the ground floor species on a quantitative basis. In other words, by this sweeping method, most of the web-builders have been included, whereas a considerable percentage of free-running species have not.

A comparison of the number of specimens collected in the herbaceous stratum with those of all habitats (Table IV) shows a close agreement in abundance. The discrepancies may be explained on several bases. First, the lycosids are rare due to their ground-dwelling habits. Other factors involved are seasonal and individual differences such as with *Eustala anastera*, which when adult is more commonly found in high bushes and trees and thus usually escapes capture by sweeping. This is confirmed by the fact that the 22 specimens of this species collected in this analysis were immature. Of greatest interest, however, is the fact that six species new to the dunes were collected during this period. This illustrates that the list of the occasional visitants and other rare, and in general less characteristic, species will not be complete for some time.

This analysis was not entirely satisfactory, as was subsequently realized, because the sweepings at the various areas had been made in different types of vegetation. In addition, it showed the spider population only during the latter half of August, 1940. Therefore, during 1941, additional sweepings were made so that the total number of sweeps was raised to 9300. If the same method of collecting used in 1940 could have been used during this period, very comparable results could have been obtained. Unfortunately, circumstances would not permit this. Therefore, the final results show 2100 sweeps at Kankakee, 4800 sweeps at Dune Acres and 2400 sweeps at Waukegan.

Table V

Analysis, by Families, of Specimens of Herbaceous Layer

	Number of specimens collected at			
Family	Waukegan	Dune Acres	Kankakee	Total
Argiopidae	40	51	17	108
Dictynidae	2	15	0	17
Micryphantidae	0	15	2	17
Theridiidae	0	15	0	15
Total web-builders	42	96	19	157
Anyphaenidae	0	2	0	2
Clubionidae	2	11	1	14
Gnaphosidae	1	0	0	1
Lycosidae	0	1	0	1
Oxyopidae	0	1	4	5
Pisauridae	0	11	0	11
Salticidae	90	152	61	303
Thomisidae	60	81	40	181
Total non-web-builders	153	259	106	518
Total spiders	195	355	125	675
Percent of non-web-builders	78.4	72.9	84.8	76.7
Number of sweeps	800	800	800	2400
Average number of sweeps per spider	4.1	2.25	6.4	3.55

Table VI includes all the sweeping data of 1940 and 1941. In analyzing these data, the unit has been 100 sweeps with the net. The percentages are based on the counts of the total number of 100-sweep units in which the non-web-builders have been collected. For example, seven specimens of *Hentzia mitrata* have been collected seven times, once in each of seven different 100-sweep units. On the other hand, there are also seven specimens of *Theridion differens*, but they were all caught in one of the units, indicating that they are locally abundant in contrast with *H. mitrata* which is more widespread but is nowhere very numerous.

One phase of this study stands out as corroborative of field conditions: the consistently high percentage of non-web-builders at Kankakee. In Table II it was shown that 72 percent of the catch were non-web-builders. This large percentage was only slightly exceeded by that of the Waukegan area which showed 73.8 percent. In Table V it is shown that Kankakee has the highest percentage (84.8) of non-web-builders as contrasted with Waukegan which has the next highest percentage (78.4). In Table VI the percentage for Kankakee is lower (74.5) though still higher than that of Waukegan (60.9) or Dune Acres (62.4).

These percentages may be treated statistically, each one hundred sweeps representing a sample of the population. The difference between the percentage at Dune Acres and Waukegan is not significant, for the chance that this variation might occur within a single population is greater than one in ten. The same is true of the Kankakee-Dune Acres populations, for the chance of variation here is one in over fifty. However, at Kankakee and Waukegan the larger percentage of non-web-builders is significantly different, for there is only one chance in over one hundred that these two percentages might occur in different samples of the same population. This shows then that, as far as the present samples are concerned, Kankakee has a larger proportion of non-web-builders than Waukegan. These findings agree well with the type of terrain, humidity, and temperatures of the three areas. That is, Kankakee has the least amount of substratum for webs and seems to be the hottest and driest, all of which seems to make poorer conditions for the web-builders.

The reasons for the drop in percentage of non-web-builders (Table VI) may be explained in several ways. Considering only the black oak species, for example, collecting data show that five hundred of the sweeps taken at Waukegan on one day, July 27, 1941, contained an excessively large number of *Neoscona arabesca*. Part of the reason for the large number of this species was that the height of their breeding season seemed to be on this day, and males and females were present in superabundance; this incident tended to reduce the percentage of non-web-builders. The small percentage of non-web-builders at Dune Acres cannot be so easily accounted for, though it seems that it must have been a seasonal matter, as these species were not found in great numbers in all of the sweepings, but were grouped in a few of the 100-sweep units. As was indicated earlier, the ideal condition for this study would be to make three visits to the areas on successive days every week throughout the year. Such a procedure would level off any effects due to seasonal abundance and give a truer picture of the yearly population. Due to the

Table VI

Quantitative Sweeping Analysis of the Herbaceous Stratum

Sw—Number of 100-Sweep Units in which species was collected; S—Number of Specimens

	FOREDUNE				PINE ETC.		BLACK OAK DUNE						MESIC PINE SWALE		PEAT MEADOW		TOTAL BLACK OAK		TOTAL ALL AREAS	
Area Concerned	DUNE ACRES		WAUKEGAN		WAUKEGAN		WAUKEGAN		KANKAKEE		DUNE ACRES		DUNE ACRES		DUNE ACRES					
No of 100-sweep units	5		4		8		12		21		23		4		16		56		93	
Species	Sw	S	Sw	S	Sw	S	Sw	S	Sw	S	Sw	S	Sw	S	Sw	S	Sw	S	Sw	S
1. *Evarcha hoyi*											1	1					1	1	1	1
2. *Hentzia mitrata*											7	7	2	2			7	7	9	9
3. *H. palmarum*													1	2					1	2
4. *Hyctia pikei*					1	2													1	2
5. *Maevia vittata*							1	1	13	24	22	211	3	10	2	2	36	236	41	248
6. *Metaphidippus capitatus*	1	2			6	42	9	28	4	5	5	9			3	25	18	42	28	111
7. *Paraphidippus marginatus*													1	1	1	1			2	2
8. *Pellenes agilis*			4	51	4	21	6	27	13	42	10	24					29	93	37	165
9. *P. borealis*	5	17			2	2													7	19
10. *P. calcaratus*									8	16	1	1					9	17	9	17
11. *P.* new sp.									1	1					1	2	1	1	2	3
12. *P.* sp. immature															2	3			2	3
13. *Phidippus audax*															2	3			2	3
14. *P. brunneus*					1	2			3	3					7	21	3	3	11	26
15. *P. clarus*			1	1	1	1	3	28			5	10			9	25	8	38	19	65
16. *P. insignarius*	1	2			3	8	5	20	16	42	12	46	2	8	10	38	33	108	49	164
17. *P. mccooki*							1	1							7	34	1	1	8	35
18. *Steatoda borealis*									1	1							1	1	1	1
19. *Sittacus palustris*															3	7			3	7
20. *Icius elegans*									1	1	5	14					6	15	6	15
21. *Zygoballus* sp.	1	1																	1	1
22. Immature salticids	2	3	1	1	3	25					1	1			2	2	1	1	9	32
23. *Peckhamia scorpionea*									1	1							1	1	1	1
24. *Coriarachne versicolor*									1	1							1	1	1	1
25. *Ebo* sp.			1	1															1	1
26. *Misumenoides aleatorius*					2	2	3	4			7	10					10	14	12	16
27. *Misumenops asperatus*							8	20	19	62	15	48	1	2	6	16	42	130	49	148
28. *Philodromus alascensis*	5	70	4	43	1	1													10	114
29. *P. aureolus*			1	2	1	1	11	81			7	25			1	1	18	106	21	110
30. *P. pernix*			1	2	1	1			2	2	2	2					4	4	6	7
31. *P.* sp. immature					2	32	1	6	3	3	1	1			1	1	5	10	8	43
32. *Thanatus* sp.											1	1					1	1	1	1
33. *Tmarus angulatus*													1	1					1	1
34. *Tibellus maritimus*															1	1			1	1
35. *T. oblongus*					3	8					2	4			2	2	2	4	7	14
36. *T.* sp. immature							3	3	1	2	2	2			9	25	6	7	15	32
37. *Xysticus banksi*			1	1	2	3	5	11									5	11	8	15
38. *X. elegans*									1	1							1	1	1	1
39. *X. fraternus*							2	2	15	30	15	50	3	7	2	2	32	82	37	91
40. *X. gulosus*			1	2	3	8	3	5	6	7					2	2	9	12	15	24
41. *X. triguttatus*					1	1	1	1									1	1	2	2
42. *X.* sp. immature									1	1	1	1	2	14	2	2	2	2	6	18
43. *Aysha gracilis*											3	6	1	1	1	1	3	6	5	8
44. *Agroeca* sp.											1	1					1	1	1	1
45. *Clubiona* sp.	1	2			3	3			2	2	10	16	1	2	10	11	12	18	27	36
46. *Micaria aurata*											1	1					1	1	1	1
47. *M.* sp.											1	1					1	1	1	1
48. *Trachelas tranquillus*											1	1					1	1	1	1
49. *Cesonia bilineata*							1	1									1	1	1	1
50. *Dolomedes* sp. immature											1	2			2	2	1	2	3	4
51. *Pisaurina mira*											2	4	4	23			2	4	6	27
52. *Lycosa rabida*											1	1			3	4	1	1	4	5
53. *Pardosa moesta*															1	1			1	1
54. *Pardosa* sp.							1	1							2	2	1	1	3	3
55. *Oxyopes salticus*									7	10	1	1					8	11	8	11
Total non-web-builders	16	97	15	104	40	163	64	240	119	257	148	502	22	73	94	236	327	999	514	1672
56. *Ceraticelus emertoni*					1	1	2	2	5	6	14	49			4	5	21	57	26	63
57. *Ceratinopsis anglicana*													1	1					1	1
58. *Erigone autumnalis*															1	1			1	1
59. *Oedothorax bidentatus*							1	1									1	1	1	1
60. Micryphantid sp.	1	1			1	1	1	1			4	4	4	7	4	6	5	5	15	20
61. *Acanthepeira stellata*	1	1	1	1	3	3									2	3			7	8
62. *Aranea displicata*							2	2	1	1					1	1	3	3	4	4
63. *A. thaddeus*									1	1	4	5	1	1	1	1	5	6	7	8
64. *Argiope aurantia*	1	1									2	2			4	4	2	2	7	7
65. *A. trifasciata*					3	3	3	3	4	5	6	7			5	11	13	15	21	29
66. *Eustala anastera*	1	1			1	1	2	2	2	2	5	9	1	2			9	13	12	17
67. *Leucauge venusta*									1	2	4	4					5	6	5	6
68. *Mangora gibberosa*									8	13	11	58					19	71	19	71
69. *M. maculata*													4	6					4	6
70. *Micrathena sagittata*											2	2	3	5			2	2	5	7
71. *Neoscona arabesca*	1	1	3	21	7	103	11	86	4	4	9	26	3	10	10	31	24	116	48	282
72. *N. pratensis*															3	4			3	4
73. *Tetragnatha laboriosa*	3	4	3	18	6	48	11	43	9	49	14	69			14	85	34	161	60	316
74. Immature argiopids									2	2							2	2	2	2
75. *Mimetus* sp.													1	1	2	3			3	4
76. *Theridion differens*							1	7			13	33			1	1	14	40	15	41
77. *T. frondeum*											3	6	2	3			3	6	5	9
78. *T. murarium*							1	1									1	1	1	1
79. *Latrodectus mactans*											2	2					2	2	2	2
80. Immature theridiids					1	1													1	1
81. *Bathyphantes formica*			1	1			1	1	1	1							2	2	3	3
82. *Frontinella communis*									1	1							1	1	1	1
83. *Linyphia pusilla*											1	1					1	1	1	1
84. *Linyphia* sp. immature							1	1			1	1	1	1	2	2	2	2	5	5
85. *Dictyna bostoniensis*	3	9	1	1	1	1	1	1									1	1	6	12
86. *D. foliacea*											1	1					1	1	1	1
87. *D. frondea*							1	2			8	18					9	20	9	20
88. *D. volucripes*											2	2			14	148	2	2	16	150
89. *D.* sp. immature					1	1	1	1			3	3	2	2	1	1	4	4	8	8
Total web-builders	11	18	9	42	25	163	40	154	39	87	109	302	23	39	69	307	188	543	325	1112
Grand total	27	115	24	146	65	326	104	394	158	344	257	804	45	112	163	543	515	1542	839	2784
Percent non-web-builders	59	84	63	71	62	50	62	61	75	75	58	62	49	65	58	44	63	65	61	60
Average sweeps per spider	4.3		2.7		2.5		3.0		6.1		2.9		3.6		2.9		3.6		3.3	

impracticability of making the study in this way, seasonal differences, such as the one readily observed in the field on the day of the great abundance of *Neoscona arabesca*, have probably caused the lowered number of non-web-builders.

An indication of the sparseness of the population at Kankakee, and its denseness at Dune Acres, is evident from the number of species collected and their abundance. Of the 114 species at Dune Acres, the herb stratum forms are fairly abundant in comparison to those of the other areas as shown by the fact that for every 2.25 (Table V) or 3 (Table VI) sweeps, one spider was collected. In contrast, at Waukegan, in which the habitat niches are less varied, one spider may be collected for every 4.1 or 2.9 sweeps. Finally, at Kankakee, the density of spiders is one-third to one-half (6.4 or 6.1) that of Dune Acres. This difference might be surmised from field observations as the herbaceous stratum at Kankakee is, for the most part, sparse, uniform grasses. At Waukegan the grasses are much more dense, while at Dune Acres there are not only more plants but also various pockets of different kinds of plants which add greatly to the habitat variety. From Table VI it is seen that the black oak area at Dune Acres has a greater density (2.9 sweeps per spider) than the mesic swale (3.6), or the foredune (4.3). Variety of habit cannot be the complete answer to the various densities, as comparison of black oak sweepings (Table VI) shows. The density at Kankakee (6.1) is still half of that of Dune Acres (2.9) or Waukegan (3.0) showing that the sparsity of the herbaceous stratum is probably the more important factor.

These differences are actual differences as may be found by comparing the 100-sweep unit samples of the populations. There is one chance in less than ten that the differences between the Waukegan and Dune Acres samples could be found in the same population, so these differences may be due to chance. In comparing the samples at Dune Acres and Kankakee, there is only one chance in more than one hundred that these samples could come from the same population. The same is true of the Waukegan and Kankakee samples. Therefore, it is statistically significant that there are less than half as many spiders in the herb stratum of the black oak at the Kankakee Dunes as there are in the same stratum of the black oak at Dune Acres and Waukegan.

Raunkiaer (1934), a Danish botanist, has made an analysis of the distribution of plants in uniform areas. Random quadrats were made over the areas concerned. Each species was then placed in one of five categories according to whether it was found in 0-20, 21-40, 41-60, 61-80,

or 81-100 per cent of the quadrats. One hundred species, as shown by Raunkiaer, would be distributed in the above classes in the following proportions respectively: 53-14-9-8-16. Kenoyer (1927) and others have shown that this distribution is also typical of animal distribution. Further, it has been shown that the more uniform a habitat, the more closely will the distribution of the species approximate the above figures. Using the 100-sweep units as separate samples, each comparable to a quadrat, such a distribution may be made from the 93 units of all types of habitats in the three areas. The 78 species found in these sweepings are distributed as follows: 64-10-3-1-0. This does not approach Raunkiaer's percentages very closely, as there are no widespread species (species in 80-100 percent of the units). These figures corroborate the field observations that the three areas contain diverse habitats and, therefore, no common species.

The black oak dunes of the three areas as a whole might be expected to be a more uniform habitat. However, the distribution of the 60 species found in this type of habitat in the fifty-six 100-sweep units (46-7-4-3-0) shows this not to be the case, as there are still no species which are found in 80-100 percent of the units. This also corroborates field observations. It was shown earlier that *Maevia vittata*, for example, was found in over 80 percent of the sweeps at Kankakee and Dune Acres, but was found in only one of the units at Waukegan. This distribution is characteristic of many species in these areas and accounts for the lack of uniformity of the black oak dunes at the three areas.

The black oak dunes of each area considered separately, however, present a different picture, even though the figures are too small for a detailed comparison. At Kankakee 21 units with 30 species show a distribution of 19-5-1-4-1; at Waukegan 12 units with 25 species, 12-5-3-2-3; and at Dune Acres 23 units with 40 species, 25-10-5-4-1. It is seen that there is at least one widespread species at each area. Therefore, it may be said that the herbaceous layer of the black oak dunes at each of the three areas is a fairly uniform spider habitat. From field observations it is apparent that the vegetation and physical factors at each area are roughly uniform.

SUMMARY

1. A study was made of the spiders of the Waukegan, Indiana, and Kankakee dune regions and the general abundance of the 180 species in each area is tabulated.

2. A quantitative and qualitative analysis of the spiders of the herbaceous layer is made from data collected by the sweeping of the vegetation.

3. The characteristics of animals of dry, open lands—cursorial burrowing, nocturnal habits—are shown to be well represented by the spiders.

4. Species requiring trees, shrubs or other similar substrata for web-building are limited in distribution in dry, open lands due to the scarcity of such substrata.

5. Low moisture content, high temperature, and direction of air movement are important factors restricting spider distribution in these dry, open lands.

6. The smallest number of species (96) is found at Waukegan because of the isolation of the area, the wind direction, and the colder, more northern location.

7. The greatest number of species (114) is found at Dune Acres, probably due to the greater variety of habitat niches.

8. Because of the foredunes at Waukegan and Dune Acres, certain species which are lacking at Kankakee are commonly found there.

9. The relative density of the spider population at the three areas indicates that there are about twice as many spiders in the herbaceous layer of the black oak dunes at Dune Acres and Waukegan as at Kankakee.

10. The spider population of the herbaceous stratum of the three areas as a whole is shown to approach the Raunkiaer Curve of Frequency, except for the absence of common species. The relatively more uniform character of the black oak dune population at each of the three areas is shown by the presence of common species, with the consequent close approach to Raunkiaer's Curve.

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